STANDARD OIL
ENGINEERED MATERIALS

Memorandum

To: S. C. DeSutter C. T. Scholl
J. K. Riley

Date: 11/6/87

From: B. R. Gardner

Copy to:

Purpose of this paper

Subject: Baselines for Trees

The Scheduler^{R} Plant Stress Monitor can be used effectively on many tree crops. Users must be more cautious than in field crops to use correct sampling techniques.

I. Three sampling problems are present in tree crops:

- Height: Most trees are too tall to allow users to see across the top of the canopy. Unfortunately, the top of a tree canopy, like any other crop, is the best place to take samples. If it is possible to sample the top of the canopy, the Scheduler would be aimed "down a row" on the sunny side of the canopy.

- Self-shading effects: Since the height of trees often precludes sampling the top of the canopy, the next method of choice is sampling individual trees. This is accomplished by standing on the sunny side of the tree and aiming at the leaves. This technique will work well on citrus and almond trees since the canopy of a single tree generally has dense foliage. Care must still be taken to sample as much sunlit foliage as possible. Remember, the Scheduler theory is based on the assumption that the leaves are sunlit. If there is some minor openness to the canopy, then the Scheduler should be aimed so that the sunlit foliage of a second tree fills in the gaps.

- Canopy geometry: The canopy geometry of some trees creates significant self-shading, even on the sunny side of the tree. In addition, many trees have an open architecture that results in a high percentage of wood and/or sky being viewed. With these trees, it is not possible to sample individual trees (although it should be possible to sample canopies if the user is above the tree).

The technique required for the sampling of these types of trees is to sample individual branches/leaves. For example, a sunlit pecan branch can be sampled effectively

if a user grabs a branch with one hand and pulls the leaves downward until a thick cluster of leaves is formed in front of his hand. Care must be taken to keep these leaves sunlit. The cluster is then sampled and the branch released. Tests on commercial pecan trees in Arizona show that 6°C (11°F) differences exist between stressed and non-stressed pecan trees using this technique.

II. More research needs to be conducted on tree crops. Developing baselines for trees requires:

- Definition of the best sampling technique for a given tree type. The best technique is the one that shows the maximum temperature difference between healthy, non-stressed trees and trees known to be experiencing severe stress. Care must be taken when a tree is said to be stressed. There are two types of stress: active and cumulative.

  Cumulative stress is the long-term result of water deficits, nutritional problems, disease, etc. The signs of cumulative stress are generally visual.

  Active stress means that the tree is exhibiting stress symptoms "today." For example, a tree exposed to long-term water stress may exhibit cumulative stress by reducing its leaf area or fruit load. If, after these symptoms develop, the cause of the stress is removed, then the tree is no longer actively stressed although it still looks stressed. To insure that a tree that looks bad is experiencing active stress, an independent measure of stress is needed. Suggested measures are:

  - Days since last rain/irrigation
  - Soil moisture
  - Leaf water potential
  - Stomatal resistance

  Scheduler measurements should be made on non-stressed trees over a crop management season. It is necessary to have data in which:

  - The sun level is above 65%
  - T_A ranges as much as possible
  - VPD ranges as much as possible
  - Preferred ranges are 65-105°F for T_A and 0-5 Kpa for VPD

- Time of day ranges between 12:00-15:00. Preferred time is 13:00-14:00 solar time

- As many samples as possible on stressed trees throughout the season to determine the maximum differences existing between stressed and non-stressed trees.

- Records of all irrigation and rainfall dates and amounts. If amounts are not available, at least provide the dates of rainfall and irrigation. These dates are critical in revealing the developing index pattern.

- Crop yields/quality: As detailed information as possible on the productivity and quality of the harvest. This information allows decisions to be made concerning critical index values.

- Statistical validity: The more treatments and replications, the better. At a minimum, the above guidelines should be followed consistently, making sure that sample areas are clearly marked and returned to each time. At least ten trees per treatment are suggested. Record the data for each tree. Three to four sample "bursts" per branch, (one-two branches per tree) if sampling branches. Five-ten "bursts" per tree if sampling whole trees. The sampling procedure should be identical for each tree.

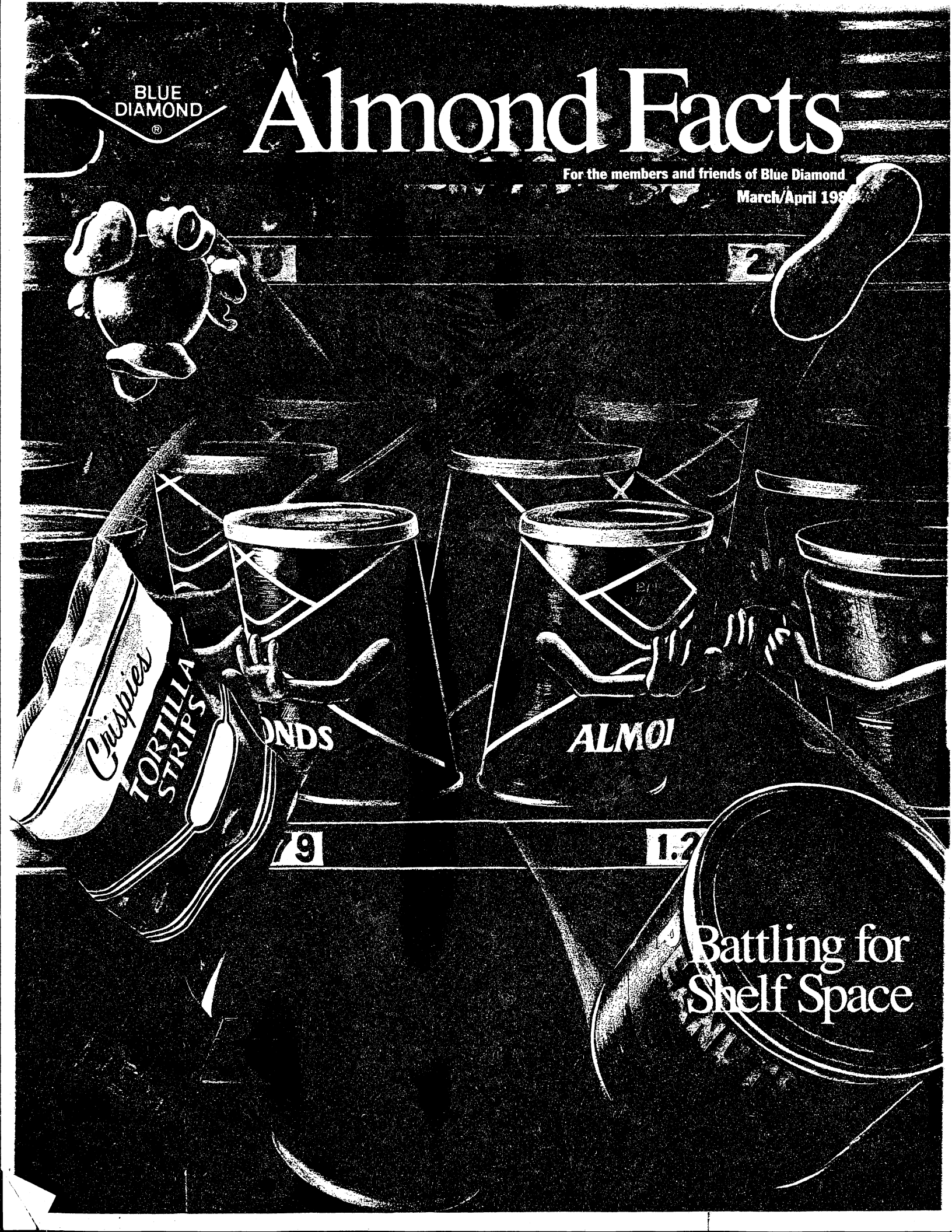
- Notes concerning cultural practices, cloud cover, windiness, activities in the field, fertilizer types and dates, cover crops, etc. should be kept.

BRG/lb

BLUE DIAMOND®

Almond Facts

For the members and friends of Blue Diamond
March/April 198



Battling for Shelf Space

BLUE DIAMOND

Almond Facts

Volume 54, No 2 March/April 1989

On the cover:
Blue Diamond is working with its network of brokers to expand space for our products in retail food outlets. Sacramento artist Connie McClennan dramatized the effort in her cover painting. See page 7 for more information.

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Irrigation Showdown

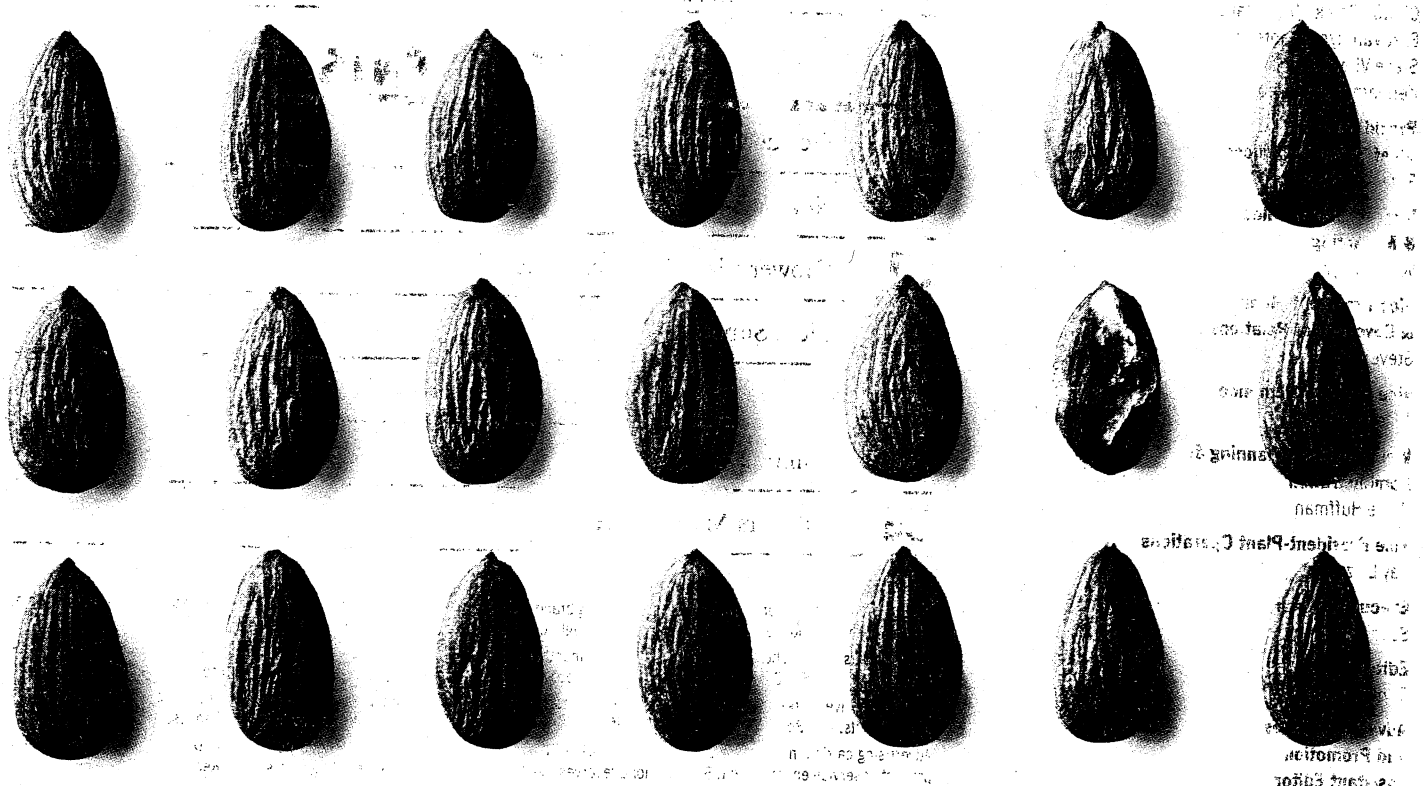
Bill Maupin takes aim to measure water stress in an almond tree.

A gunslinger squints in the summer sun as it climbs toward high noon. He looks left, he looks right, then strides down the lane, his boots stirring up the dust as he goes. Spotting potential trouble ahead, he stops, raises a gun from his side, takes aim and fires.

An almond tree takes a direct hit but is still standing tall when Bill Maupin "holsters" his pistol. He then looks down at the portable computer pack on his hip and reads data that tells him it's time to irrigate the orchard. Maupin, a representative for Standard Oil Engineered Materials, is a new breed of "gunslinger" starting to appear on more farms. The gun-shaped device connected to a portable computer is actually an infrared thermometry device called the Scheduler® plant stress monitor.

The gun contains a set of four sensors and infrared thermometry that generates data for leaf temperature, ambient temperature, relative humidity and solar radiation load. The information is processed in the 64K microprocessor. This portable computer can be programmed with crop stress indexes for any of 25 different crops, including almonds. The device is accurate to 1/10th of a degree, and measures not only plant temperatures, but also the immediate environment around a plant or tree.

"It's a marked improvement over conventional irrigation scheduling systems which are limited to measuring soil moisture," says Maupin. Conventional soil moisture moni-



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toring systems don't gauge other factors that can cause plant stress, such as diseases, insect damage and soil compaction.

"This is a very user-friendly system. It only takes about 30 minutes to learn to use it," Maupin says. "When taking a reading, you always need to have the sun at your back and aim at green, sunlit leaves. You don't want to hit bare soil or sky, which will skew the reading," he explains.

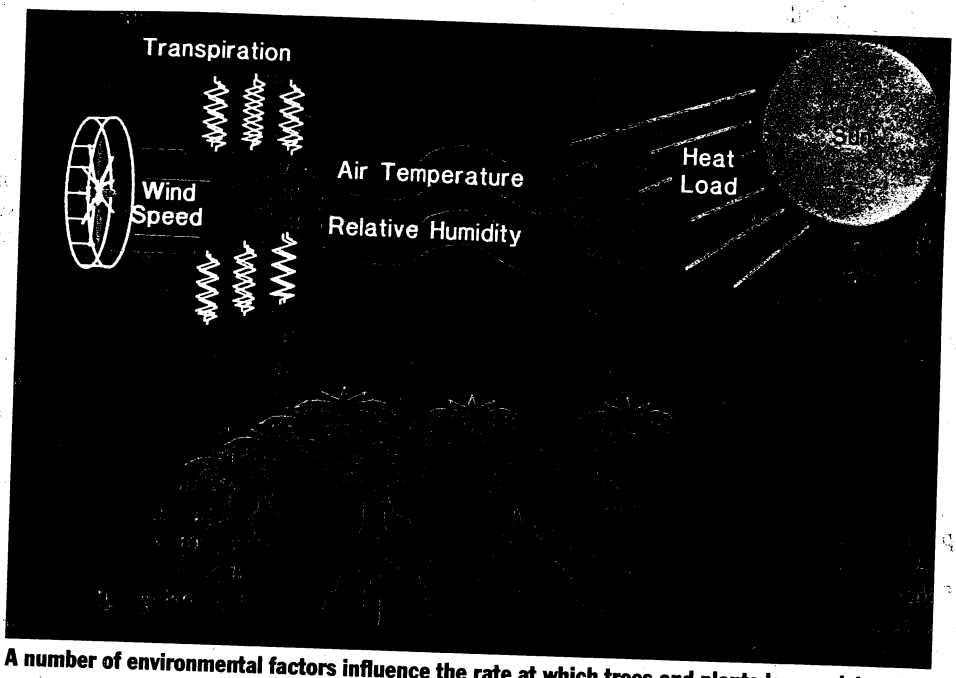
"Infrared technology isn't new, but we made it user friendly and portable," says Maupin.

The "gun" can be used by itself, or in conjuncture with Standard's new CropLink weather stations. The CropLink weather station continually monitors air temperature, relative humidity, wind conditions and plant water stress. Again, there's nothing new about field weather stations, which have been used in agriculture for over 30 years. But Maupin says this is the first infrared field weather system, which can relay data to a home computer every three and a half minutes without use of wires or radio frequencies. All that is needed is a clear line of sight between the field station and base station, which can be located up to a mile apart. Greater distances can be linked by using other stations connected in a "daisy chain."

The system not only supplies plant stress and evapotranspiration data for irrigation scheduling, but can also be set to trigger frost alarms in the winter. Maupin says evapotranspiration data tells a grower the rate at which his crops are losing soil moisture into the air. Accumulated ET records between watering can be used to determine when and how much to irrigate a crop.

This technology is all geared to help growers detect plant stress days before it becomes apparent to the naked eye. "By the time you can observe plant stress with your eyes, damage has already been done which may affect your crop yield," Maupin says.

The Scheduler, which weighs eight pounds, sells for about $4,300. The Crop Link weather station package is about $6,700.



A number of environmental factors influence the rate at which trees and plants lose moisture.

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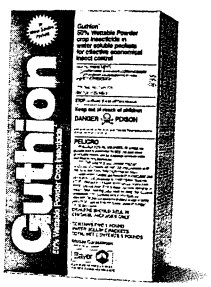

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Water Stress in Trees

Overview

Water comprises between 50 and 95 percent of the fresh weight of trees, depending on whether the tree part being measured is a shoot, limb, root or fleshy fruit. As much as 90% of the water absorbed by tree roots is lost to the air through transpiration. When soil moisture decreases to the point that transpiration rates decrease, relative to well-watered trees, tree growth and fruit development are negatively affected. Excess soil moisture can decrease the availability of oxygen to roots. Oxygen deficiency in the soil can severely inhibit or alter root development. Root density tends to be greatest in unsaturated soils which are moist enough to allow trees to transpire at the maximum rate, while allowing roots access to high levels of oxygen. 80% or more of the total water most trees transpire is extracted from the top three feet of soil (Wample, 1981a.)

Moisture stress is associated with :

a.) decreased photosynthesis and transpiration rates
b.) decreases in respiration
c.) increases in abscisic acid (ABA). High ABA levels are associated with stomatal closure and the inhibition of growth. It may take several days to several weeks for ABA levels to return to normal after stress has been removed.
d.) reduced production of cytokinins. Cytokynins are related to the rate of growth and potential size of some fruits, such as apples. Decreased cytokinin levels allow ABA to become more active.
e.) increased ethylene production. Ethylene is responsible for premature fruit drop and leaf senescence.
f.) reduced production of Gibberellins (GA). GA promotes larger fruit size.
g.) Auxin levels increases under mild moisuture stress , but decreases as stress increases. The ratio of auxins and GA has an effect on fruit thinning and the development of the abscission zone in the stem of fruits and leaves (Wample, 1981b).
h.) leaf cupping. This is analogous to leaf curling in corn. Leaves cup when the transpiration rate is lower than the potential evaporation rate. If the curling does not disappear over-night, it probably indicates low soil moisture.
i.) defoliation. excess moisture stress can cause leaf-defoliation. If a defoliated tree is irrigated the same year, the tree may bloom and leaf-out again, using the buds that would have produced fruit and leaves the following year.
j.) die-back. Water stress during the summer can cause dieback. Dieback can also be caused by excessive water (oxygen stress).

Mid-season, during the period of active growth, flower buds are set for the next season. Any stress which affects flower bud formation will not be until the following crop season. Mild water stress may increase flower bud formation.

Plants can be classified according to the behavior of their stomata. Succulents close their stomata during the day-time. Some plants keep their stomata fully open throughout the day and close them at night. Other plants open their stomata fully in the morning, partially close them during mid-day (when potential transpiration is greatest) , open them fully in the late afternoon, then close them at night. Extreme air temperature, elevated carbon dioxide levels, wind and water stress can cause stomatal closure (Kennedy and Fujii, 1981) (Figures 1 and 2).

SOIL TEMPERATURE

Soil temperature also affects root growth. Although most plant roots can grow when the the soil temperature ranges between 5 C (40 F) and 35 C (96 F), the optimum soil temperature for maximum root growth is usually between 20 and 25 C (68-77 C). Root growth is more sensitive to temperature effects than shoot systems. Soil temperature is significantly influenced by soil moisture levels in three ways : a) evaporative cooling from the surface, when the soil surface is moist. b) initial irrigation water temperature. The source of water (wells, irrigation ponds, canals, etc.) affects its initial temperature during irrigation. This in turn affects soil temperatures in the root zone. c)The frequency and type of irrigation. Flood irrigation, sprinklers, micro-jets and drip-irrigation are each used with varying frequencies and spatial distributions. Each system will produce different effects on root zone soil temperatures.

The root activity of fruit trees increases in late winter and early spring as the soil warms. Root activity reaches a peak about blossom time and begins declining as shoot growth increases. A second period of root activity begins in late summer and early fall and continues into late fall and early winter, until soil temperatures in become too low (Wample, 1981b).

FIGURE 1

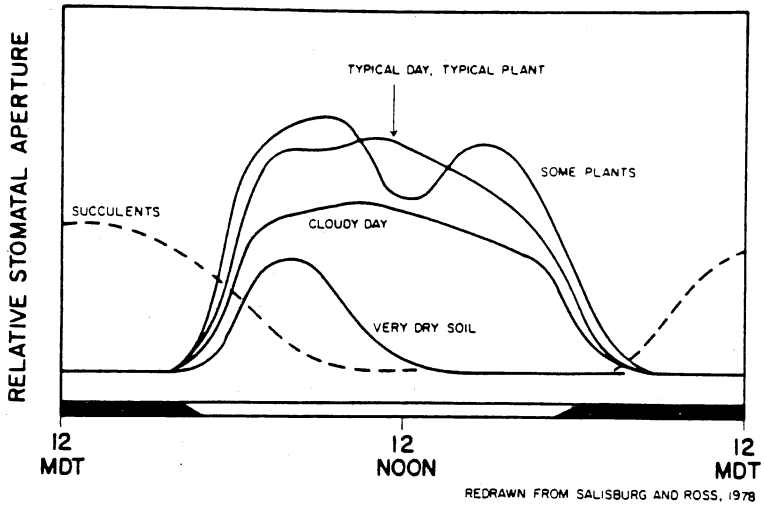

Fig. 7–Daily stomatal aperture changes under various environmental conditions. Some plants experience stomatal closure near mid-day due to a slight water deficit. Stomatal apertures are also affected by light intensity ("cloudy day") and the amount of water in the soil available for transpiration ("very dry soil").

FIGURE 2

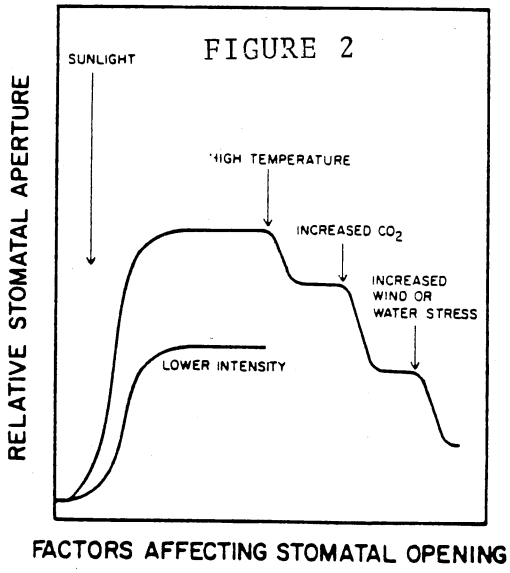

Fig. 8–Various environmental factors can decrease stomatal aperture, decreasing transpiration and photosynthesis.

FIGURE 3

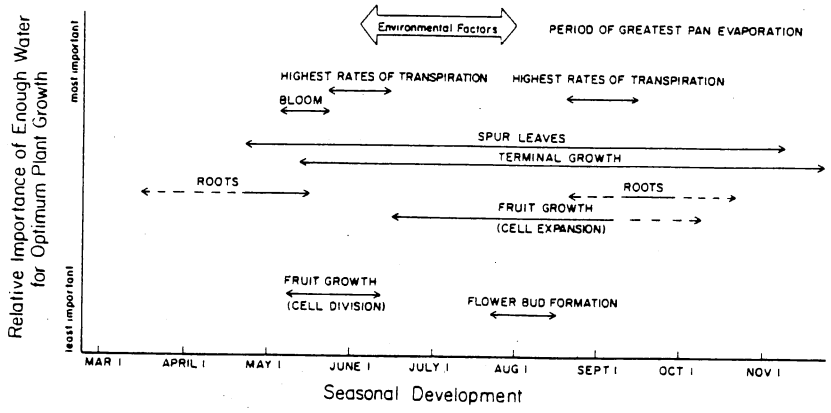

Fig. 22–Time scales for the importance of water for optimum growth of an apple tree.

TABLE 1

Table 13. Estimated Percentage Cold injury to Almond Fruit Buds After 30 Minutes Exposure to Various Temperatures[1]

		Temperature °F							
Variety	**Stage**	**29**	**28**	**27**	**26**	**25**	**24**	**23**	**22**
Peerless	Full bloom		25	45	75	100			
	Showing pink				25	50	75	100	
Ne Plus Ultra,	Full bloom			25	50	75	100		
I.X.L.,Mission	Showing pink						60	80	100
Drake	Full bloom				25	50	75	100	
	Showing pink						25	50	75
Nonpareil	Full bloom					20	40	60	75
	Showing pink							10	20

[1] Table prepared by Harry B. Hansen, Fruit Frost Meteorologist (retired), U.S. Weather Bureau, Chico.

THE WEATHER AFFECTS THE CROP REGARDLESS OF SOIL MOISTURE STRESS LEVEL

By definition, water stress occurs when the potential transpiration rate (based on ambient conditions) exceeds the capacity of a tree to transpire. Crop damage resulting from water stress depends on a) the part of the season the stress occurs b) the severity of the stress c) the duration of the stress, ususally measured in days. Water stress during the daytime will not affect crop performance if sufficient soil moisture is available that the trees can recover turgor at night. This is why pre-dawn leaf water potential measurements are often used to characterize the severity of stress from a preceeding day. If insufficient water is available for a tree to fully recover turgor, then damage to the crop may occur.

At moderate potential evaporation rates, shoot growth is slow until about 2:00 p.m., when it begins a period of rapid development that continues until about 10:00 p.m. Growth then slows until the following day. Fruit size decreases between sunrise and about 2:00 p.m. then begins increasing in size during the late afternoon and evening.

At high potential evaporation rates, shoot growth is delayed until the late afternoon and evening and never achieves as high a rate of growth as when the potential evaporation rate is more moderate. Fruit size fluctuations will be larger (Wample, 1981b). Photosynthesis declines at high potential evaporation rates, despite high transpiration rates (no moisture stress). One purpose of recent irrigation studies has been to find ways to modify the ambient temperature experienced by crops to avoid the detrimental effects of high potential evaporation rates.

Traditionally, trees have been irrigated whenever soil moisture decreases to less than 50-60% of available soil moisture. The availability of solid set irrigation, trickle irrigation, over-tree irrigation and methods of directly monitoring tree water status (such as the pressure chamber and the Scheduler Plant Stress Monitor) present new options for controlling orchard irrigations. Instead of asking the question "How dry should the soil become before it is irrigated ?" the question for the future should be "What level of plant moisture deficit is optimum for this orchard ?" (Proebsting, 1981).

GENERAL MANAGEMENT CONSIDERATIONS

Plant Species

Resistance to overirrigation. Apples, pears and European plums resist overirrigation better than peaches or cherries.

Root Stocks

Root stocks differ in their resistance to oxygen stress and water logged conditions. Roostocks vary with respect to root size, distribution, and growth patterns. Little is known about the specific performance of many commonly used rootstocks.

Tree Age

Young trees have small root systems and may be water stressed at the same time that larger trees have adequate water. Young trees often continue vigorous activity in late summer, when older trees are going dormant. This activity must be stopped before cold resistance can be developed.

Tree Spacings

Tree spacings affect the frequency with which irrigation is required.

Cover Crops

Cover crops provide competition for available soil moisture and nutrients. Unless the cover crop is managed properly, damage to the crop may result.

Pruning Practices

Weak spurs create the tendency for a tree to overset the desired number of fruit. Fruit tends to be small and ripens prematurely. Proper pruning practices will prevent this problem. If the problem occurs, then pruning-for-spur-renewal will result in lost production for three years.

Orchard History

The performance of an orchard crop is affected by the cumulative effect of the treatment it has received during previous years, from both management practices and the weather. Any practice or event that affects the root system will have long range effects on the tree.

(Proebsting, 1981).

Pollination

Orchard crops can be pollinized in 3 ways :

a. self-pollination

b. cross-pollination with other varieties of the same crop. The physical arrangement of cross-pollinating varieties strongly affects the number of flowers that ultimately become fertilized. It is essential that pollen-shed from one variety be properly timed to coincide with bloom on the other variety. This timing can be affected by weather patterns and soil moisture stress.

c. insect pollination. Honey bees are the most common insect pollinators. Weather conditions affect the activity of honeybees, and therefore the ultimate number of fertilized flowers. Rain can wash wash pollen out of pollen sacks or off the stigma. Strong winds can cause remove pollen from flowers. The optimum temperature for pollen germination is between 60 and 75 F. Pollen germination is severly reduced if the ambient temperature is below 60 F or above 80 F. Pollen tubes may burst at 90 F and higher. Bee management is an important activity for many orchard growers.

USING THE SCHEDULER ON TREE CROPS

In order to successfully use the Scheduler on a tree crop, the following principles must be observed :

1. Research must first demonstrate that there is a large difference in the stomatal resistance or transpiration rate between leaves from stressed and non-stressed trees. If such differences do not exist, it is not possible for the stress index to provide meaningful information.

2. A tree-specific measurement technique must be established. Tree canopies may be open or closed and composed of large or small leaves. Canopy architecture may induce large amounts of shading on the "sunny" side of the tree. Large amounts of wood may or may not be exposed to view. Regardless of canopy architecture, ONLY GREEN, SUNLIT LEAVES SHOULD BE SAMPLED. Any other type of surface (shaded leaves, wood, sky) represents a source of error. This requirement makes it difficult to sample the entire canopy of some trees. Instead, single branches or clusters of leaves must be sampled. This requirement cannot be avoided if success is expected.

3. The sites you sample should be consistent with your irrigation needs.

4. Make readings only during the proper environmental conditions.

5. Make interpretations based on a knowledge of the normal index patterns for your crop. Use the specific recommendations provided by Carborundum for your crop as a starting point. You will likely modify these recommendations slightly as you gain experience with the Scheduler on your crop.

GENERAL GUIDELINES

Sampling Techniques

Sample in the orchard, not from roadways (unless the roadway is in the orchard). It is essential to be at least 50 feet away from the edge of the orchard to avoid influences from roadbeds and surrounding areas.

Stand on the sunny side of a tree, with the sun at your back. This places you in a position to sample the hottest leaves on the tree. If the hottest leaves are not stressed, then the entire tree can be assumed to be unstressed.

At your first sample location, take repeated readings until the averages of consecutive samples are within 0.5 index of each other. This insures that the hardware has adequately adjusted to the environment.

Use one of the following aiming techniques, depending on the structure of the specific trees you plan to measure :

a. If the tree has a closed canopy, with little or no self-shading, aim at the sunny side of the tree and take 10-15 samples across the diameter of the tree. This technique is used in APPLE trees.

b. If the tree has an open canopy, or significant self-shading, but has a dense leaf structure on individual branches, then sample 5-10 sunny branches per tree. Aim the Scheduler along the axis of the branch. Hold the Scheduler gun approximately parallel to the ground. If the tree does not have a fully closed canopy, aim the gun so that a second tree is directly in line with the target tree. This technique is used in ALMOND trees.

c. If the tree has an open canopy, or signficant self-shading, and has an open leaf structure on individual branches, then it will be necessary to artificially create a sampling surface. Remember, the only valid samples are taken on GREEN, SUNLIT leaves. An artificial sample surface can be created by grabbing a branch and pulling the leaves toward you. The leaves will form a cluster directly in front of your hand. If you take care not to shade this cluster of leaves , the nose of the Scheduler gun can be placed directly on this leaf cluster and a sample taken. At least 5 branches per tree should be sampled in this manner. While this sampling technique is slower than methods a and b, it is still much faster than any any other method used to sample leaf condition on trees. This technique is used in PECAN trees.

Planning Observations

Include in the areas you choose to sample :

a. recently irrigated areas. Index values on these areas can be used as a reference for comparison to other areas. These areas will likely be the least stressed areas.

b. areas where soil moisture is monitored. These areas will help you determine how much water is required when you decide to irrigate.

c. areas where problems may occur, or irrigation is anticipated.

Environmental Conditions

Stable environmental conditions help insure proper readings.

Readings should occur no earlier than 30 minutes before solar noon. Solar noon occurs when the sun is directly south of you. Readings should occur no later than 3 hours after solar noon. At any rate, be consistent on when you take readings. In frequently cloudy areas, the time of day to make readings may need to be adjusted so that readings are completed before clouds typically develop.

Take readings only in bright sunshine. Clouds that are not in front of the sun are not a problem. When the sun is interrupted by a passing cloud, wait at least 2 minutes for the crop to warm-up after the sun reappears.

Low wind (less than 10 miles per hour) is preferable. When readings are made under high windspeed conditions, the index readings may be 1-2 stress unitis lower than under low windspeed conditions.

Normal Index Trends

When clouds move in front of the sun, the index will decrease rapidly.

It is common to see an increase of 1 to 2 stress units after a heavy irrigation. This pattern is caused by a lack of oxygen in the soil profile. THis is especially evident in heavy soils. Then, there is a decrease in the index as drainage occurs. The index will remain low for a period of time and then gradually increase until the next irrigation or rainfall event.

ALMONDS

General Facts

There are significant varietal differences in bud sensitivity to frost conditions (Table 1). After the bloom stage, all varieties respond essentially the same (25 % injury after 30 minutes at 29 F and close to 100 % kill after 30 minutes at 27 F.) Because almonds are so sensitive to cold, 1 or 2 F means the difference between negligible injury and disastrous kill. The extreme importance of accurate temperature data at all times is self-evident. Air temperature sensors should be mounted to avoid radiational cooling, otherwise temperature readings will be artificially low, especially on clear nights (Brewer, 1981).

Almonds develop in three distinct phases. Stage I encompasses bud-break, bloom, pollination and the growth of the fruit to its maximum size. Stage I typically occurs between March and May. Stage II typically occurs during May. During Stage II, the embryo grows to full size. During Stage III (June-September), the embryo continues to gain weight, but does not change in size (Figure 4). Research indicates that mild water stress during stage III does not affect final nut size of the following year's crop (Krauter, 1988, private communication).

Scheduler Recommendations

If the air temperature is below 85 F, the index should remain less than 1.0 between bloom and full nut size. If the air temperature is greater than 85 F, the index may go up to 3.0 before irrigation between bloom and full nut size.

After full nut size, the index may go as high as 5.0 without damaging the crop.

Normal stress levels should be maintained between 0.0 and 3.0 during most of the growing season.

APPLE TREES

General Facts

Excessive irrigation or rainfall into the summer months often reduces flower bud formation. Flower bud formation is also inhibited by moderate moisture stress and competely inhibited by severe stress. The size of a fruit load also affects flower bud formation. A light crop load in one year will likely result in a heavy flower bud formation the next year. In general, the lower the stress level a tree experiences, the larger the number of flowers it will produce the next year. Moisture stress can produce a greater "June drop" and may cause as much as a 3 fold reduction in fruitlet retention after pollination.

Fruit growth and final fruit size is significantly affected by moisture stress, and oxygen stress depending on the severity, duration, and timing of the stress. Early in the season, oxygen deficiency, caused by over irrigation, reduces the potential fruit size. Spring-time soil moisture stress stress rarely occurs. Beginning about 3-4 weeks after bloom (early June), potential fruit size is signficantly affected by moisture stress. Stress which lasts longer than 1 week results in decreased fruit size. Stress which lasts less than 1 week may actually increase fruit size once the stress is alleviated.

Fruit quality is known to be affected by moisture stress. Cool wet weather during harvest reduces moisture stress and results in increased fruit cracking, softening and bruise susceptibility. (Wample, 1981b).

The stomata of apples are all on the lower side of the leaf (the side that is normally away from the sun). Mid-day partial stomatal closure is a normal event during periods of high potential transpiration. Fruiting trees transpire more water than non-fruiting trees. The stomata of apples appear sensitive to the vapor pressure deficit of the air (Jones et al., 1985).

Moisture stress (high index readings) reduces the size of apples. With some varieties, total tonnage will also be reduced by stress. With other varieties, the effect of moisture stress on total tonnage will be small. The effect on total yield depnds on whether or not stress causes blossoms to abort or fruit to drop. This is a variety dependent characteristic known by most growers.

Scheduler Recommendations

Index values should range between -3.0 and +3.0 and should generally be below 1.0. Irrigate when the index exceeds 2.0. Size reduction can be expected if the index exceeds 3.0 for an extended period of time.

STONE FRUITS

General Facts

Moisture stress has little effect on fruit growth and quality until stage III, the period of final swell. The soil can remain relatively dry throughout pit hardening with little effect. During stage III, moisture stress significantly reduces fruit growth. Often moisture stress occurs not as a result of inadequate soil moisture, but as the result of excess fruit loads. The lack of moisture stress during harvest is associated with increased fruit cracking, softening and bruise susceptibility (Wample, 1981b).

Scheduler Recommendations

A baseline has been developed for peaches, but insufficient research has been conducted which would allow specific recommendations to be made. Since these fruits are high in water content, we believe that low stress readings should be maintained on stone fruits.

THE HIGH GENERIC BASELINE

There are many more tree crops than baselines available for the Scheduler. We have developed a general "all purpose" baseline for use on tree crops. It is called the "HIGH" baseline. This baseline will respond properly to stress (the higher the stress, the higher the readings), but it may not function with an effective 0 - 10 scale. It may have a wider, or potentially, narrower range. A user can calibrate this baseline for his specific crop by comparing HIGH index readings on normal and severely stressed areas (severe means physiologically severe, with stomates that are closed and leaves that are transpiring little water.) Once the normal index patterns for a healthy crop are established, by monitoring the crop through several irrigation cycles, irrigations can be initiated when index readings depart signficantly from normal.

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AVOCADO TREES

General Facts

The stomatal resistance of well-water avocado leaves is high than citrus leaves, ranging between 8 and 20 sec/cm. By comparison, field crops such as corn, cotton and wheat will have stomatal resistances less than 1.0 sec/cm. (Jones et al., 1985).

Scheduler recommendations

The Scheduler is not recommended for avocado trees at this time.

CITRUS TREES

General Facts

The effect of water stress on citrus fruit quality depends more on when the stress occurs rather than the degree of stress. Midsummer stress tends to increase acidity, degree Brix and rind thickness, while stress early or late in the season cause reductions. Juice content is highest in trees stressed early and late and lowest in trees stressed during mid-summer (Germana et al., 1985). Fruit sizes decrease approximately 1 cc for each 1 F (per day) that a tree is warmer than a well-watered control tree. The daily variation in leaf water potential for citrus, apple, apricot and pears is similar. Citrus leaves transpire water at only 1/3 to 1/4 the rate of apple and apricot trees (figure 5) (Jones et al., 1985). The stomatal resistance of well-watered citrus leaves varies throughout the day and ranges between 2 and 5 times the stomatal resistance of leaves from well-watered crops such as corn (Syvertsen and Albrigo, 1980, Syvertsen ,1985). Leaf-air temperature differences are only weakly correlated with solar radiation inten or vapor pressure deficit (VPD), primarily due to the thickness c leaves and their relatively high stomatal resistances in the well- state (Syvertsen and Levy, 1982).

Scheduler Recommendations

The Scheduler is not recommended for use on citrus at this time.